Special Instructions for Evidence Copy Box Identification

Documents in this patent application scanned prior to the scan date of this document may not have a box number present in the database. The documents are in the same box as this paper. If the patent application documents that do not have a box number are stored in more than one box, a copy of this form is placed in each box. Check the database box number for each copy of this form to identify all of the evidence copy box numbers for documents that do not have a box number.

X **The documents stored in this box are original application papers scanned and endorsed by PACT and imported into IFW.**

☐ **The documents stored in this box were scanned into the IFW prototype for GAU 1634, 2827,or 2834.**

Indexer, place and X in only one box above to indicate the documents placed in this box that were previously scanned in PACR or IFW and will not be scanned again.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 September 2001 (07.09.2001)

PCT

(10) International Publication Number
WO 01/65709 A1

(51) International Patent Classification[7]: H04B 1/10, 1/707, H04L 12/28, 1/00, H04Q 7/36

(21) International Application Number: PCT/US01/40089

(22) International Filing Date: 12 February 2001 (12.02.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/516,130 1 March 2000 (01.03.2000) US

(71) Applicant: HOME WIRELESS NETWORKS, INC. [US/US]; 3145 Avalon Ridge Road, Norcross, GA 30071 (US).

(72) Inventor: MC INTOSH, P., Stuckey; 59 East Park Lane, N.E., Atlanta, GA 30309-2725 (US).

(74) Agent: PRATT, John, S.; Kilpatrick Stockton LLP, Suite 2800, 1100 Peachtree Street, Atlanta, GA 30309 (US).

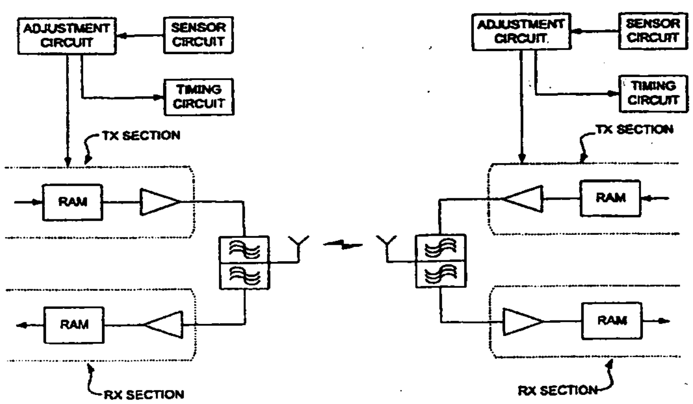
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: COMMUNICATIONS SYSTEMS WHICH AVOID SOURCES OF INTERFERENCE



(57) Abstract: Systems, devices and methods for communicating digital information in a manner that avoids periodic or non-periodic interference such as that radiated by microwave ovens and other interference sources. The invention contemplates four general approaches, and combinations of those approaches. First, transmission of frames may be synchronized or phaselocked to absence of periodic interference. Second, transmission of frames may be advanced or delayed based on whether the periodic interference affects transmission of headers and trailers on the frames. Third, transmission of slots within frames may be controlled based on sensing presence or absence of the interference. Such control may be based at least in part on comparing the transmission of slots to the waveform of the periodic interference in order to establish a transmission pattern. Fourth, transmission of slots within frames, or frames themselves, may be discontinued during periods when interference is sensed. Such systems, devices and methods are particularly useful for wireless local access networks, where delay times are short, high data rates are at a premium, and potential for industrial, scientific and medical apparatus-generated interference is real.

WO 01/65709 A1

COMMUNICATIONS SYSTEM ROBUST AGAINST PERIODIC INTERFERENCE

Radio spectrum is becoming scarcer. Techniques for interference suppression are becoming increasingly important. Techniques for frequency reuse, spatial diversity, code division multiple access all are becoming increasingly important. Spread spectrum communications is permitted in what are called the ISM bands (industrial, scientific, medical) because spread spectrum communications is inherently resistant to jamming and interference. There is no spectrum etiquette required in any of these spread spectrum bands and every system is left to its own devices regarding interference avoidance and communications reliability. There is also no statutory protection from interference as is afforded cellular communications and broadcast radio or television, for instance. Consequently, devices which transmit or receive radiofrequency (RF) signals must address and overcome interference in these bands. As additional communications needs place demands on the available bandwidth, spread spectrum techniques alone are not sufficient to guarantee reliability of communications and suppression of increasing levels of interference in such bands and environments. It becomes increasingly important to incorporate other methods, such as forward error detection, forward error correction and error concealment.

Active interference suppression also gains significance with increasing scarcity of spectrum. The 2.4 GHz band, one of the three ISM bands, has been used principally for data communications. Techniques are needed which will better support the transport of voice, video, and multimedia communications. These applications require a very high quality of service because of their real-time, continuous-connected nature. There are a variety of these real-time, continuous-connected applications which are difficult to implement effectively and

reliably in the ever-crowded radio spectrum, particularly in the 2.4 GHz band, even ignoring untoward or undue RF interference.

Microwave ovens are a ubiquitous and deleterious source of microwave interference, particularly in the 2.4 GHz band. Microwave ovens radiate swept frequency, pulsed-amplitude signals which are broadband and difficult to avoid. Such pulses often occupy the entire, otherwise-available 2.4-2.4835 GHz band. They have relatively high effective radiated power (ERP), as much as 1 watt ERP in certain orientations. Any communications systems or devices which operate in the 2.4 GHz band in the residential environment, and in many commercial environments where a real-time, continuous-connection is called for, must therefore contend with this microwave oven-radiated interference. Techniques for forward error detection, forward error correction, error concealment, and active interference suppression are all therefore important techniques to consider in a microwave oven radiation environment.

While microwave ovens appear to be an unpredictable and broadband source of interference, the inventor has found that microwave oven interference is in fact detectable, identifiable and predictable owing to the fact that microwave ovens employ single-rectifier, voltage-doubler type power supplies. They generate interference in the form of 8.33-millisecond-wide pulses with 8.33 milliseconds of dead time between pulses in the United States, which obviously derives from the United States 60 Hz standard alternating current line voltage waveform. (For areas where 50 Hz power is the standard, the interval is 10 ms). This interference is therefore synchronized to the line frequency. The frequency-sweep pattern is also linked to line frequency, and the amplitude envelope resembles a limited and halfwave-rectified, 60-Hz waveform. Given the increasing level of intelligence available in conventional DSP-centered digital communications systems, one can therefore readily detect, identify and classify microwave oven interference. Equipment which can detect, identify and classify

the interference, can also synchronize its own transmissions to this AC-power-line-synchronized communication. When a communications system is able to synchronize its transmissions to the interfering source, there are a number of benefits that accrue:

1. Packet error rate (PER) is substantially reduced.

2. Preclusion of transmissions during the time that the interference source is active results in increased battery life for portable devices due to less net transmit time.

3. Because there is no transmission of frames during the times the interference source is active, there is no need to retransmit these frames. Throughput then becomes more predictable and steady and can, in fact, double.

The issues are similar in some ways to military communications, electronic surveillance and electronic countermeasures systems where active avoidance and cancellation of intentional interference is the objective. Principles according to the present invention work with FSK, m-ary PSK, m-ary QAM, CDMA, OFDM (DFT), VWB / PPM monopulse, and other digital modulating schemes, so long as the equipment features the ability to detect, identify and classify a wide variety of "threats" (not simply microwave ovens) and synchronize, discontinue, or otherwise control its transmissions accordingly, adjust its frame lengths and / or otherwise customize its transmissions to counter the threat system. It would have the ability to effectively avoid and to coexist with the threat system. However, such systems are different from military systems in many ways. Consumer electronics, such as wireless telephones and wireless local area networks, must be price competitive, small and attractively packaged, and

oth rwise implem nted in a way that emphasizes low cost, low power consumption, efficient manufacture, and small size.

There are a number of techniques that can be used for synchronizing the system to the interference source. First, the system may simply phase lock its frame rate and / or frame length to the periodic interference. For example, systems according to the present invention can sample the AC-line frequency directly from their own power supply and use this as a frequency input to a digital phaselock loop, needing only to adjust phase in order to synchronize transmissions directly to the microwave interference. Transmitting during the proper time is then essentially a matter of selecting the correct phase during which to transmit (i.e., the half cycle which is not occupied by microwave oven interference). Electrostatic or magnetic pickups may be used to synchronize to line frequency without being hard-wired to the AC power system. Additionally and perhaps most preferably, transmissions can simply be synchronized to microwave interference by merely monitoring the interference at RF with the receiver portion of an RF modem or with similar, wider-band receiver circuitry.

A second technique is via frame push-pull using error detection on a front porch and back porch of transmitted pulse train. For example, frames which are slightly less than 8.33 milliseconds in length may be transmitted and the system clock or other circuits which govern transmission times may be advanced or retarded, speeded or slowed. Such timing may be based on reports of receipt of errors from a header byte or a trailer byte on the transmitted frames, or it may be based on detection of line voltage, detected RF radiation or electrostatic or magnetic interference as discussed in the paragraph above. Alternatively, if every frame is transmitted with a known code word as a header and another known code word as a trailer on each frame, an interference source that begins to encroach upon the frame causes errors in either the header or the trailer frame. Transmission timing may be advanced or delayed, such as by advancing or delaying, speeding

or slowing the system clock, either actually or by pulse swallowing or stuffing, in order to move the frame back into a "saddle" position so that the interference source is not affecting the header or trailer bytes. Such timing may be based on a combination of such techniques.

Third, in a system such as the ETSI Digital Enhanced Cordless Telecommunications (DECT) standard or the less common W-DECT standard (8-slot frames vs. 12-slot DECT frames and FHSS), it may be appropriate to transmit only on available slots in particular frames. Since the frame rate of DECT and W-DECT is established at 10 milliseconds, it is not an option to redesign such systems to operate using an 8.33-millisecond frame structure simply to address interference suppression. Instead, it makes sense in such a case to advance or delay timeslots, or transmit only on interference-free slots, so that transmissions are always occurring during interference-free time periods. For example, a 12-slot DECT system with a 10 millisecond frame rate allocates 5 milliseconds for transmission and 5 milliseconds for reception. Interleaving such a system into an RF environment with a periodic, 8.33-millisecond interference source may be accomplished by transmission only on slots which are not "covered" by the interference, and queueing or otherwise delaying or reformatting the information to be transported on respective slots in successive frames, all in accordance with detected interference. Fourth, such techniques may be combined with the fifth general approach discussed beginning in the paragraph below.

Fifth, in systems which operate in random interference environments, or environments featuring multiple sources of interference, some of which may be periodic and some not, it may be appropriate to eschew synchronicity and / or push / pull and instead transmit only on available slots in particular frames, or in available frames. Detection in such cases may govern transmissions on interference-free slots or frames, and queueing or otherwise delaying or

reformatting the information to be transported on later slots in successive frames, or in successive frames may be accomplished to ensure the entire data stream is transported.

Techniques according to the present invention permit high quality of service for real-time, continuous-connective systems in residential and commercial environments where microwave ovens and other sources of interference are prevalent. Other results include increased battery life, greatly reduced frame error rate, reduced need for expensive, complex active interference-suppression and / or cancellation techniques, less need for error concealment techniques, less need for forward error detection and forward error correction, and more time-bandwidth product available for transport of content with less frame overhead.

Brief Description of the Drawings

Fig. 1 is a series of timing diagrams which illustrates a first embodiment of avoiding interference according to the present invention, according to principles of synchronicity.

Fig. 2 is a series of timing diagrams which illustrates a second embodiment of interference avoidance according to the present invention, according to a push / pull approach.

Fig. 3 is a series of timing diagrams which illustrates a third embodiment of interference avoidance according to the present invention in accordance with a slot timing technique useful for the DECT standard.

Fig. 4 is a series of timing diagrams which illustrates a variation of the third embodiment of interference avoidance according to the present invention in accordance with a slot timing technique useful for the W-DECT standard.

Fig. 5 is a series of timing diagrams which illustrates a fourth embodiment of interference avoidance according to the present invention, according to a hybrid timing - detection driven approach, which is useful for the DECT standard.

Fig. 6 is a series of timing diagrams which illustrates a variation of the fourth embodiment of interference avoidance according to the present invention, according to a hybrid timing - detection driven approach.

Fig. 7 is a series of timing diagrams which illustrates a fifth embodiment of interference avoidance according to the present invention, according to a detection driven approach.

Fig. 8 is a functional block diagram showing systems, devices and circuits for implementing embodiments, methods and approaches according to a preferred embodiment of the present invention.

Fig. 9 is a functional block diagram showing slot insertion and recovery systems, devices and circuits for implementing embodiments, methods and approaches according to a preferred embodiment of the present invention.

Fig. 10 is a more detailed functional block diagram showing slot insertion systems, devices and circuits for implementing embodiments, methods and approaches according to a preferred embodiment of the present invention.

Detailed Description

A. First G neral Approach – Phaselocking

Figs. 1A - 1E schematically illustrate a first approach for avoiding interference according to the present invention. Fig. 1A represents a sine wave with a period of 16.667 mS, or more simply, a 60 hertz sine wave, the waveform associated with alternating-current line voltage on standard US power lines. Fig. 1B represents idealized output of a typical microwave oven. Because of particular decisions implemented for transformation of the alternating current line voltage into a form more suitable for powering the microwave oven, the conventional microwave oven power supply provides power only during half of the power cycle. Fig. 1C shows the points in time when the microwave is not producing any RF interference, thereby leaving the frequency band at 2.4 GHz available for RF devices. The cross-hatched blocks are times when the microwave oven is interfering with such devices and the clear blocks are times when the microwave oven is not interfering.

Fig. 1D displays the data stream which may be utilized in a wireless network or more generally between two wireless devices whether or not considered to be in a network. Blocks with upwardly directed arrows represent the uplink from subscriber stations to a network control unit, and blocks with downwardly directed arrows represent the downlink from the network control unit to subscriber stations. More generally, blocks with upwardly directed arrows represent link transmission in a first direction, and blocks with downwardly directed arrows represent link transmission in a second direction. Such complementary directions may be upstream / downstream, downstream / upstream, or otherwise in complementary directions between any wireless devices.

Fig. 1E combines Figs. 1C and 1D to show the first technique. The shaded blocks with the upwardly and downwardly directed arrows are data blocks

that would be interfered with by the microwave oven. Accordingly, a first technique according to the present invention properly synchronizes transmission of blocks in the half cycles during which the microwave oven is not radiating RF interference. Such transmissions are represented by clear blocks as shown in Fig. 1E.

B. Second General Approach -- Push / Pull

Figs. 2A - E show a second approach according to the present invention. Fig. 2A shows a portion of the output of typical microwave oven. Again, the cycle time is 16.667 mS and the time available for transmission is 8.333 mS. Fig. 2B shows two large cross-hatched blocks which are the times when the microwave oven is radiating RF noise. That figure also shows a smaller three block grouping that represents a data frame that a wireless device or the network is attempting to transmit. The data frame consists of a header packet, the actual data packet, and a trailer packet. In the example shown in Fig. 2B, the header packet is interfered with by the output of the microwave oven. Knowing this, the wireless device or network can retard, delay or slow its clock so that the transmission of subsequent packets fits within the times when the microwave is not radiating RF noise. Fig. 2C represents the transmitted frame being delayed in time so that the entire frame will fit within the time when the microwave is not radiating RF noise. Fig. 2D shows the trailer packet of the transmitted packet being interfered with by the noise radiated by the microwave oven. Knowing this, the wireless device or network can advance its clock or otherwise adjust timing so that the transmission of subsequent frames will fit within the times when the microwave is not radiating RF noise. Fig. 2E shows the transmitted frame being advanced in time so that the entire frame will fit within the time window when the microwave is not radiating RF noise.

C. Third General Approach -- For DECT or W-DECT Transmissions

Figs. 3A - H show a third approach according to the present invention, which is employed to accommodate transmissions according to the ETSI Digital Enhanced Cordless Telecommunications (DECT) or W-DECT standard (the W-DECT variation being shown more fully in Figs. 4A - H below). Fig. 3A once again shows a sine wave with a period of 16.667 mS, or more simply, a 60 hertz sine wave representative of standard alternating current line voltage in the United States (obviously the same techniques work with 50 Hz line voltage as in Europe, or any other periodic waveform). Fig. 3B once again shows idealized output of a typical microwave oven. Fig. 3C shows the points in time when the microwave oven is not generating any RF interference, thereby leaving the frequency band at 2.4 GHz available for RF devices. The cross-hatched blocks are times when the microwave oven is interfering with such devices and the clear blocks are times when the microwave oven is not interfering. Fig. 3D schematically shows the structure of the data stream for a DECT device. The frames are 10 mS in duration with the up and down links being 5 mS each. Since the frames are longer than the amount of time when a microwave oven is not radiating interference into the spectrum, one cannot rely exclusively on either of the two earlier described methods. Fig. 3E represents the actual slot structure of a DECT device. Each up and down frame consists of 12 slots, each 0.41667 mS in duration (in the case of W-DECT, 8 slots, each being 0.625 mS in duration). The slots which are cross-hatched with a upward pointing hatch (to the left) are up-link slots that are interfered with, while the downward point hatch represent down-link slots that are interfered with.

Figs. 3F, 3G and 3H represent a continuation in time of the events shown in Figs. 3B, 3D, and 3E, respectively. Due to the cyclic nature of the microwave oven interference and the data frames, the number of free slots available for the transmission of data is also cyclic and forms a pattern relative to the periodicity of the microwave oven interference waveform. Below is a table showing such a

pattern, by displaying the number of slots available in each frame (each such frame consisting of an uplink and a downlink frame) of a DECT transmission which are not subject to microwave oven interference.

Frame	0	1	2	3	4	5	6	7	8	9	10	11
Up	0	12	0	8	8	0	12	0	8	8	0	12
Down	4	4	12	0	12	4	4	12	0	12	4	4

For the uplink, the pattern or cycle is 0 12 0 8 8, and for the down-link, the pattern or cycle is 4 4 12 0 12. Using this repeated pattern or cycle, the data frames can be transmitted during the available time slots. Obviously, a constant integer offset of slot numbers may be employed with no loss of performance. In the actual operating environment, it may be necessary to combine this third technique with principles according to the second technique in order to advance or retard the DECT transmissions based on actual radiation of the microwave oven. A similar table may be constructed for the 8-slot, W-DECT system.

Figs. 4A - H show a variation of the third general approach for the W-DECT standard. Fig. 3A once again shows a sine wave with a period of 16.667 mS, or more simply, a 60 hertz sine wave representative of standard alternating current line voltage in the United States (obviously the same techniques work with 50 Hz line voltage as in Europe, or any other periodic waveform). Fig. 4B once again shows idealized output of a typical microwave oven. Fig. 4C shows the points in time when the microwave oven is not generating any RF interference, thereby leaving the frequency band at 2.4 GHz available for RF devices. The cross-hatched blocks are times when the microwave oven is interfering with such devices and the clear blocks are times when the microwave oven is not interfering. Fig. 4D schematically shows the structure of the data stream for a W-DECT device. The frames are 10 mS in duration with the up and down links being 5 mS each. Since the frames are longer than the amount of

time when a microwave oven is not radiating interference into the spectrum as in the DECT case described above, one cannot rely exclusively on either of the two earlier described methods, pure synchronicity or push/pull. Fig. 4E represents the actual slot structure of a W-DECT device. Each up and down frame consists of 8 slots, each being 0.625 mS in duration. The slots which are cross-hatched with a upward pointing hatch (to the left) are up-link slots that are interfered with, while the downward point hatch represent down-link slots that are interfered with.

Figs. 4F, 4G and 4H represent a continuation in time of the events shown in Figs. 4B, 4D, and 4E, respectively. Due to the cyclic nature of the microwave oven interference and the data frames, the number of free slots available for the transmission of data is also cyclic and forms a pattern relative to the periodicity of the microwave oven interference waveform. Below is a table showing such a pattern, by displaying the number of slots available in each frame (each such frame consisting of an uplink and a downlink frame) of a W-DECT transmission which are not subject to microwave oven interference.

Frame	0	1	2	3	4	5	6	7	8	9	10	11
Up	0	8	0	5	5	0	8	0	5	5	0	8
Down	2	2	8	0	8	2	2	8	0	8	2	2

For the uplink, the pattern or cycle is 0 8 0 5 5, and for the down-link, the pattern or cycle is 2 2 8 0 8. Using this repeated pattern or cycle, the data frames can be transmitted during the available time slots. Obviously, a constant integer offset of slot numbers may be employed with no loss of performance. In the actual operating environment, it may be necessary to combine this technique with principles according to the second technique in order to advance or retard the W -DECT transmissions based on actual radiation of the microwave oven.

Similar t chniques may be used for any transmission format, regardless of the number of slots in a frame or any other manner in which data is formatted, arranged, sequenced or sent.

D. Fourth General Approach -- Hybrid

Figs. 5 and 6 show a hybrid approach partially using the techniques shown in Figs. 3 and 4, and partially using detection driven techniques. Fig. 5 shows an irregular noise spike that covers a period where 7 up slots could have been otherwise inserted, and a pulse that covers a period where 2 up and 2 down slots could have been sent according to the DECT standard using the techniques shown in Fig. 3. According to the present invention, when the system can include sensor functionality, of the sort discussed with reference to Fig. 7 below, to sense the presence of such noise or interference or other non-periodic noise, interference, or intrusions whatsoever into the spectrum. When that happens, systems according to the present invention can resend the slots, or they can interrupt sending the slots and begin sending again when at the end of the anomaly. Fig. 6 shows similar techniques for the W-DECT standard, where the first anomaly covers a period where 5 slots could have been sent, and the pulse covers a period where 2 up and 2 down slots could have been sent. In this case, the system can continue to assume that in the future, the periodicity tables discussed with reference to Figs. 3 and 4 are still valid; if the system begins to understand that there is a pattern or periodicity, it can adjust or recalculate the tables for timing of slot insertion and sending.

E. Fifth General Approach -- Detection Driven.

Figs. 7A - E show a fifth general approach for interference avoidance according to the present invention. Fig. 7A represents an environment which suffers not only periodic interference such as that radiated by a microwave oven,

but also random or nonperiodic anomalies or sources of interference. Phaselocking and push / pull techniques may not present a viable interference avoidance approach in such environments, nor may variations or different techniques such as discussed with reference to Figs. 3 and 4 or 5 and 6.

Instead, the present system includes detection techniques in order to alter performance in the face of such anomalies. For example, systems according to the present invention can sample the AC-line frequency directly from their own power supply; electrostatic or magnetic pickups may be used, and / or interference can be monitored at RF with the receiver portion of an RF modem or with similar, wider-band receiver circuitry. to synchronize to alter the insertion and/or sending of slots or frames.

This detection technique works in combination with any of the techniques shown in Figs. 1 - 6, including synchronicity, push/pull, and slot insertion techniques used with DECT or W-DECT. In combination with those techniques the general rule is that when an anomaly is detected, sending or insertion of slots or frames is interrupted and resumes when the anomaly is over, or the slots or frames can simply be resent to cover the period. As described above with reference to Figs. 5 and 6, a periodicity table can be recalculated or altered if and when the system begins to sense pattern or periodicity; at some point, the system can choose to abandon notions of adhering to a schedule if noise or anomalies become overly intrusive. In any event, the present invention includes systems and process which control timing of slot or frame insertion or sending only according to detected noise. This approach is especially adapted for those environments where, for example, the periods between interference substantially exceeds frame transmission length.

As shown in Figs. 7B and 7C, where DECT frames are shown only for purposes of convenience and in a nonlimiting way, the interference may be

detected using electrostatic pickup devices, RF antennas, or other suitable sensors electric or magnetic manifestations of interference. Such sensors provide output which is employed to govern and control assembly of data into frames or slots available for interference-free transmission, and / or timing of transmission, both upstream and downstream. An anomaly occurs and is detected in the second uplink frame and occupies a period that covers 5 slots. Insertion and/or sending of these can be interrupted, or they can be resent in the next uplink opportunity when no anomaly is being detected. Transmission from both ends, uplink and downlink, resumes when the anomaly has transpired, and continues until the pulse shown to begin in the third downlink frame. There insertion and / or sending is once again interrupted until the pulse has transpired; the packets which would have been sent during that period are inserted and sent, whether or not insertion and / or sending was interrupted. This technique is shown in Fig. 7E. Alternatively, entire frames which were wholly or partially coincident with anomalies may have their insertion and / or transmission interrupted and sent or resent. Fig. 7D shows this approach. The interrupted and sent or resent frames and slots, respectively, are shown with hatching in 7D and 7E.

F. Implementation.

Implementation of the general approaches disclosed above may occur in any desired conventional or unconventional manner. Fig. 8 is a functional block diagram showing a preferred embodiment of RF transmission functionality, housed in a communications device, in which such approaches may be implemented. The device may be a wireless telephone, a wireless local access device, a wireless voice / data network, or any other device which operates on the 2.4 Ghz band or other band subject to interference. Wireless networks that accommodate both voice and data communications are disclosed in, for example, USSN 09/292264 filed April 15, 1999 for a "Wireless Communications Gateway

For A Home or Small Office," USSN 09/229848 filed January 12, 1999 for a "Wireless Communications Gateway For A Home or Small Office," USSN 09/083726 filed May 22, 1998 for "Communications Web With Personal Communications Links for PSTN Subscribers," USSN 08/843700 filed April 16, 1997 for "Communications Webs For PSTN Subscribers," and USP 5,805,582 issued September 8, 1998 for a "Home Personal Communications System," which documents are incorporated herein by this reference as if fully set forth herein. Fig. 8 schematically shows a sensor circuit, an adjustment circuit, and a timing circuit which govern the timing of the data stream. Any or all of these circuits may be at least partially coextensive. The first approach, phaselocking or synchronizing the transmitted frames to periodic interference, may be accomplished using conventional phaselocking techniques and circuits, coupled with, as desired, input from sensors such as line voltage sensors, electrostatic sensors, or RF antenna sensors, which produce output corresponding to at least presence of interference. In the second, push / pull approach, the system clock or other circuits which control transmission timing, may be advanced or retarded, or speeded or slowed, in order to shift the transmitted frame relative to the periodic interference source in time. The first approach may be combined with the second approach for periodic signals.

Fig. 9 schematically shows a system in which slots may be inserted using a slot insertion device, conventional or otherwise. Figure 9 schematically shows a sensor circuit, an adjustment circuit and a timing circuit which govern timing of the data stream and insertion of data. Any or all of these circuits may be at least partially coextensive. This is suitable for the techniques shown in Figs. 3 - 6, and 7D. Here, sensors of the sort disclosed above govern the times and slots when transmission occurs: When interference is sensed, transmission does not occur, and data designated for interference-precluded slots must be queued or otherwise stored or delayed for transport in later slots.

Fig. 10 shows in more detail how increments of data, wh ther frames, packets, slots or otherwise, can be subject to timing, insertion and / or transmission interruption, sending, or resending according to the present invention. Increments in a data stream are fed to a device for data insertion which is controlled as discussed above (shown as the "slot machine") in Fig. 10A. The increments are timed, inserted, interrupted, resent, and / or sent according to any of the techniques or processes discussed above. Fig. 10B shows a schematic timing diagram, where the first row shows the increments that would be sent in a perfect world. For whatever reason, whether synchronicity, push/pull, detection driven, or any combination of these, systems according to the present invention have the ability to send increments of data in time windows or periods other than those for which they were originally scheduled. Thus, one increment may be interrupted, sent, resent, sent or resent repeatedly, or any combination, in order to ensure that the data gets through.

Systems and techniques according to the present invention may be adapted to reference data concerning various radiators such as microwave ovens, frequency-hopping spread spectrum communications systems such as that known as "Metricom" at the time of this application, DS and FHSS IEEE 802.11 emitters, and other sources of interference. According to a first technique, DSP, fuzzy logic or related techniques may be employed to "learn" and store / or the nature of interference sources, in order to modify both time and frequency of transmissions to optimize throughput in real time, and to reference the stored information on future occasions in order to classify and more efficiently modify the transmissions to optimize throughput. Second, equipment as shipped may contain stored information about known interference sources, and thus be adapted more quickly and efficiently to identify, classify and avoid such sources by modifying transmissions. Third, such equipment may be accessible for updating on-line or on-air as new interference sources are identified at the factory or by other third parties. Such updating can occur via the PSTN, the Internet, or

via air interface. Any or all of these techniques for storing and using interference source information may be combined in order to achieve quicker and more efficient source identification, classification and avoidance.

The foregoing is provided for purposes of disclosure of a preferred embodiment of the present invention. Modifications, changes, additions or deletions to the disclosed embodiments need not depart from the scope or spirit of the invention.

What is claimed is:

1. A method for enabling a communications device to emit digital information transmissions that avoid periodic interference, comprising:

a. sensing presence or absence of said interference;

b. formatting said digital information into frames whose transmission length is equal to or shorter in time to the periods when said interference is absent; and

c. adjusting timing of said transmission of frames based on said sensing to occur only when said interference is absent.

2. A method according to claim 1 further comprising formatting said digital information into frames whose transmission length is equal to or shorter than half of the periods when said interference is absent.

3. A method according to claim 1 wherein adjusting timing of said transmission of said frames includes adjusting the clock rate applied to circuits controlling the timing of said transmissions.

4. A method according to claim 1 wherein sensing presence or absence of said interference includes sensing the waveform of line current.

5. A method according to claim 1 wherein sensing presence or absence of said interference includes sensing electrostatic manifestations of said interference.

6. A method according to claim 1 wherein sensing pres nce or absence of said interference includes sensing radiofrequency manifestations of said interference.

7. A method according to claim 1 in which said device forms part of a network, and at least some of the process is carried out in separate devices in the network.

8. A method for enabling a communications device to emit digital information transmissions that avoid periodic interference, comprising:

a. formatting said digital information into frames whose transmission length is shorter in time than the periods when said interference is absent;

b. supplying a header and a trailer to each of said frames;

c. sensing when transmission of said headers or said trailers is interfered with by said interference;

d. adjusting timing of said transmission of frames based on said sensing to occur only when said interference is absent.

9. A method according to claim 8 wherein adjusting timing of said transmission of said frames includes adjusting the clock rate applied to circuits controlling the timing of said transmissions.

10. A method according to claim 8 in which said device forms part of a network, and at least some of the process is carried out in separate devices in the network.

11. A method for enabling a communications device to emit digital information transmissions that avoid periodic interference, comprising:

a. providing an information transport stream formed of a plurality of slots within a plurality of frames;

b. sensing when transmission of slots within said frames is interfered with by said interference;

c. tracking said interference of slot transmission as a function of timing of said periodic interference;

d. determining which slots are available for transmission based on said tracking of said interference of slot transmission as a function of timing of said periodic interference;

e. placing said digital information in said slots which are available for transport, based on said determination; and

f. transmitting said slots at times when interference is absent based at least in part on said tracking of said slot transmission interference as a function of timing of said periodic interference.

12. A method according to claim 11 wherein adjusting timing of said transmission of said slots includes adjusting the clock rate applied to circuits controlling the timing of said transmissions.

13. A method according to claim 11 in which said device forms part of a network, and at least some of the process is carried out in separate devices in the network.

14. A method according to claim 11 in which a pair of frames is longer in transmission time than the periods when the periodic interference is absent.

15. A method according to claim 11 in which the step of providing an information transport stream formed of a plurality of slots within a plurality of frames comprises forming an information transport stream in accordance with DECT standards.

16. A method according to claim 11 in which the step of providing an information transport stream formed of a plurality of slots within a plurality of frames comprises forming an information transport stream in accordance with W-DECT standards.

17. A method for enabling a communications device to emit digital information transmissions that avoid interference, comprising:

a. providing an information transport stream comprising a pluralilty of frames;

b. sensing presence or absence of interference;

c. discontinuing transmission of frames in the presence of said interference in order to transmit an interrupted information transport stream only in the absence of said interference; and

d. formatting digital information into said frames of said interrupted information stream.

18. A method according to claim 17 in which said device forms part of a network, and at least some of the process is carried out in separate devices in the network.

19. A method according to claim 17 wherein sensing presence or absence of said interference includes sensing the waveform of line current.

20. A method according to claim 17 wherein sensing presence or absence of said interference includes sensing electrostatic manifestations of said interference.

21. A method according to claim 17 wherein sensing presence or absence of said interference includes sensing radiofrequency manifestations of said interference.

22. A system for altering the period of time in which data slots are sent on a DECT radio link, including;

a. a source for producing a data stream comprising a plurality of data slots;

b. a sensor for detecting anomalies in at least part of the radio spectrum occupied by the radio link;

c. a slot insertion device for inserting slots into the data stream; and

d. an adjustment circuit coupled to the sensor and the slot insertion device for controllably inserting slots into the data stream according to anomalies sensed by said sensor, the adjustment circuit comprising a circuit for controlling the timing of the data stream.

23. A system according to claim 22 in which the adjustment circuit includes a device for interrupting insertion of data slots into said data stream.

24. A system according to claim 22 in which the adjustment circuit includes a circuit for phaselocking the data stream to a desired waveform.

25. A system according to claim 22 in which the adjustment circuit includes a clock circuit and a circuit for adjusting the clock circuit that controls timing of the data stream.

26. A system according to claim 22 in which the sensor includes a line voltage sensor.

27. A system according to claim 22 in which the sensor includes an electrostatic sensor.

28. A system according to claim 22 in which the sensor includes an RF sensor.

29. A system according to claim 22 in which the data stream is a W-DECT data stream.

30. A system for altering the period of time in which increments of data are sent on a radio link, including;

a. a source for producing a data stream comprising a plurality of data increments;

b. a sensor for detecting anomalies in at least part of the radio spectrum occupied by the radio link;

c. an adjustment circuit coupled to the sensor for altering the period of time in which the data increments are sent depending on anomalies sensed by said sensor.

31. A system according to claim 30 in which the adjustment circuit includes a device for inserting data increments into said data stream.

32. A system according to claim 31 in which the adjustment circuit includes a device for interrupting insertion of data increments into said data stream.

33. A system according to claim 30 in which the adjustment circuit includes a circuit for controlling the timing of said data stream.

34. A system according to claim 33 in which the adjustment circuit includes a circuit for phaselocking the data stream to a desired waveform.

35. A system according to claim 33 in which the adjustment circuit includes a clock circuit and a circuit for adjusting the clock circuit that controls timing of the data stream.

36. A system according to claim 30 in which the sensor includes a line voltage sensor.

37. A system according to claim 30 in which the sensor includes an electrostatic sensor.

38. A system according to claim 30 in which the sensor includes an RF sensor.

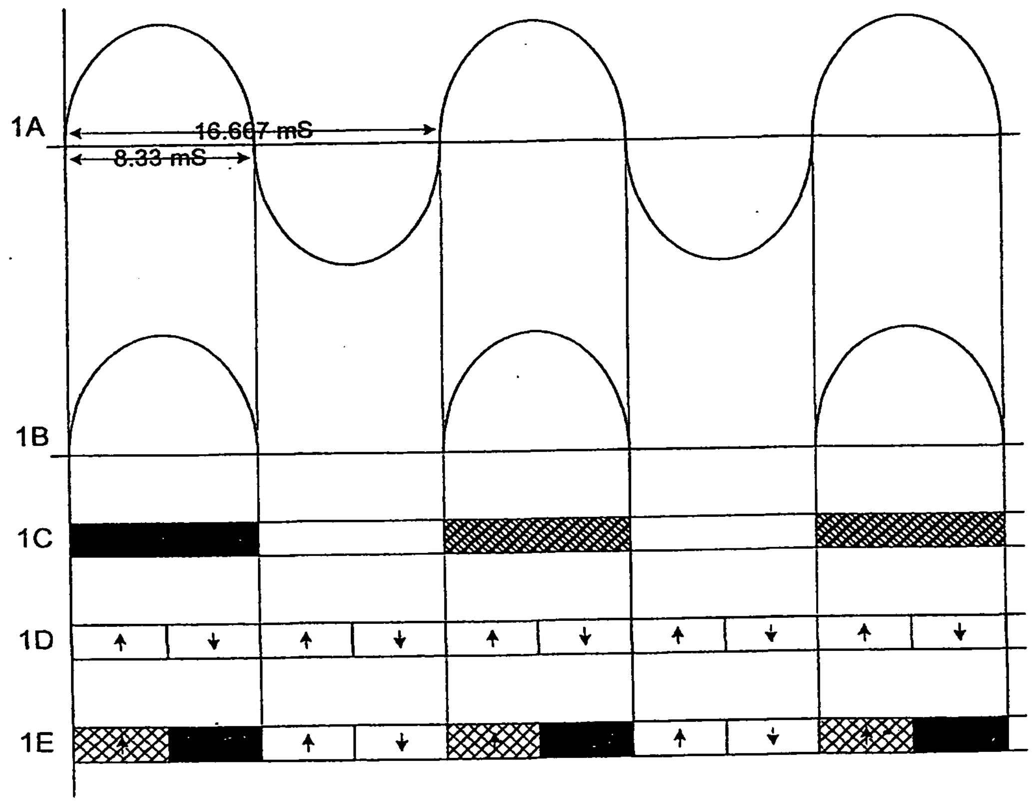


FIG. 1

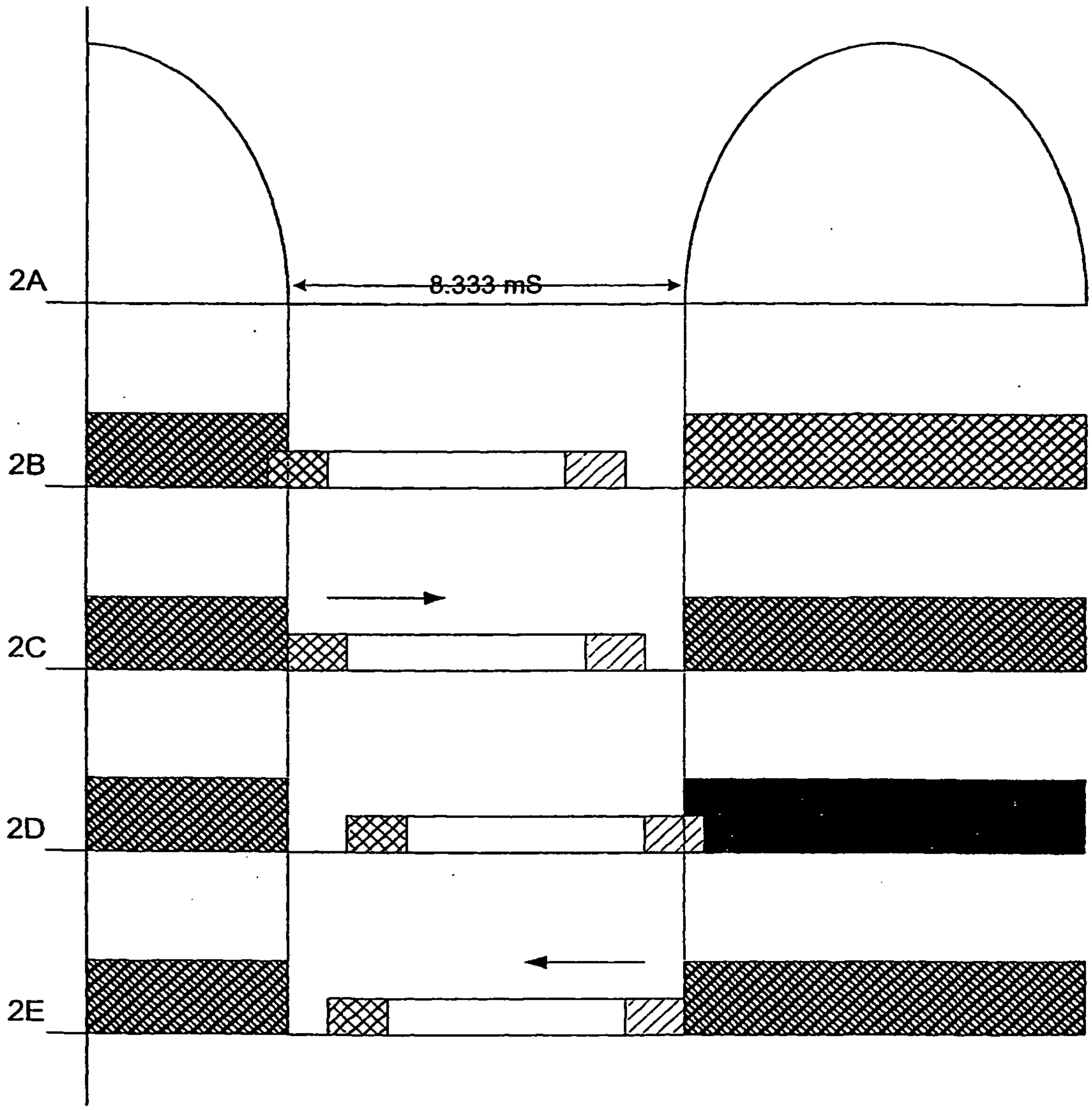


FIG. 2

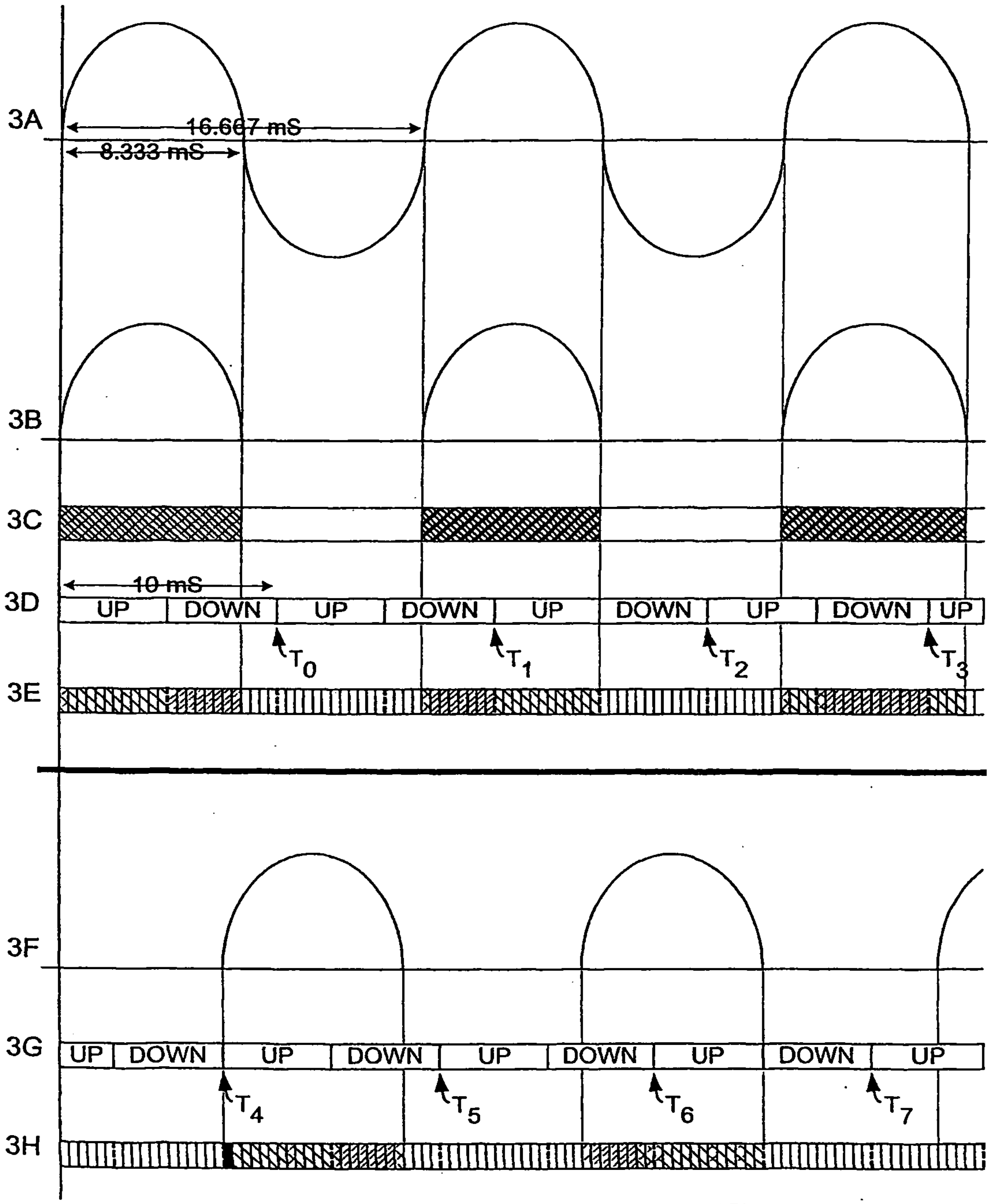

3A
16.667 mS
8.333 mS
3B
3C
10 mS
3D
UP DOWN UP DOWN UP DOWN UP DOWN UP
T_0
T_1
T_2
T_3
3E
3F
3G
UP DOWN UP DOWN UP DOWN UP DOWN UP
T_4
T_5
T_6
T_7
3H

FIG. 3

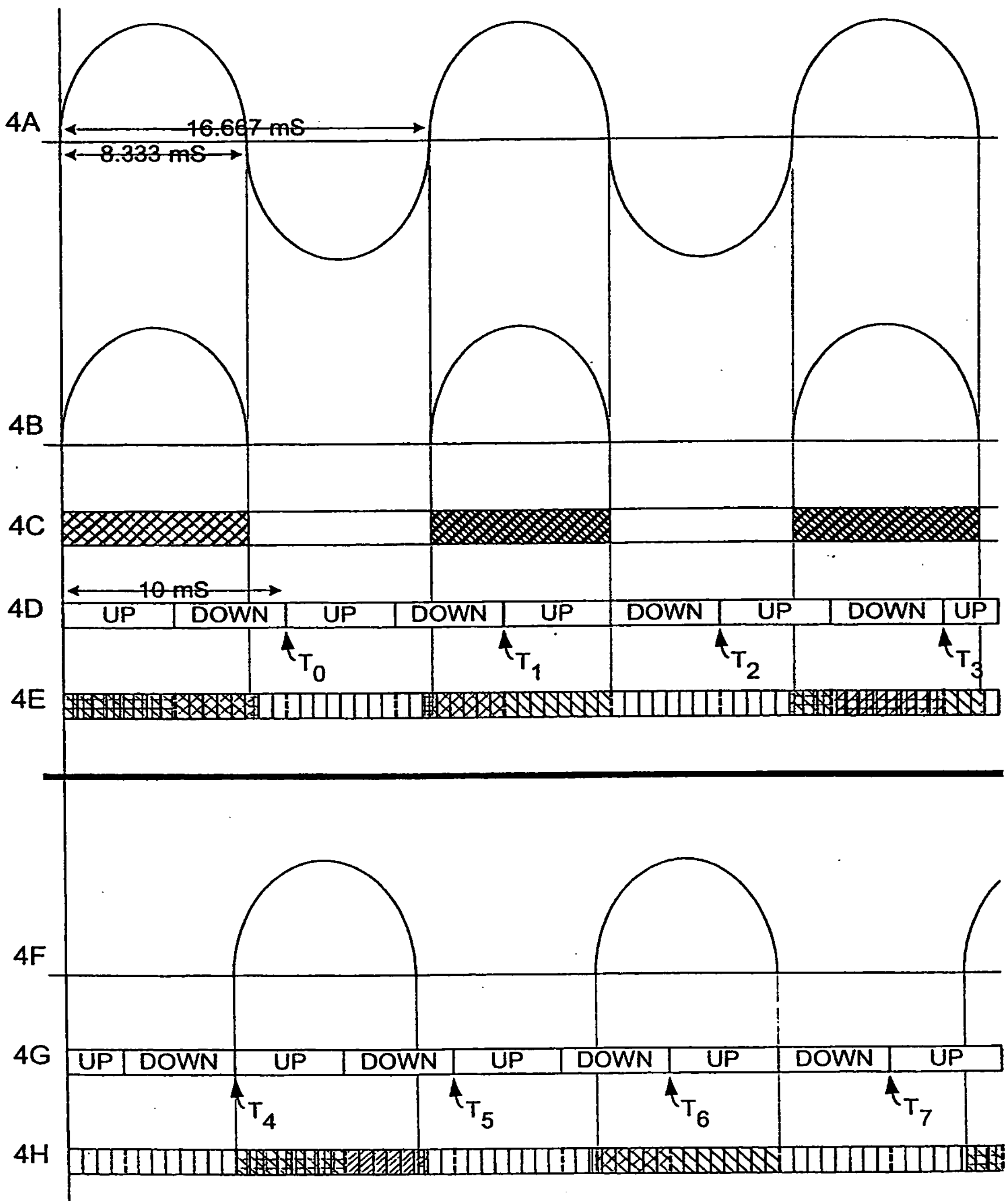

4A
16.667 mS
8.333 mS
4B
4C
4D
10 mS
UP
DOWN
UP
DOWN
UP
DOWN
UP
DOWN
UP
T_0
T_1
T_2
T_3
4E
4F
4G
UP
DOWN
UP
DOWN
UP
DOWN
UP
DOWN
UP
T_4
T_5
T_6
T_7
4H

FIG. 4

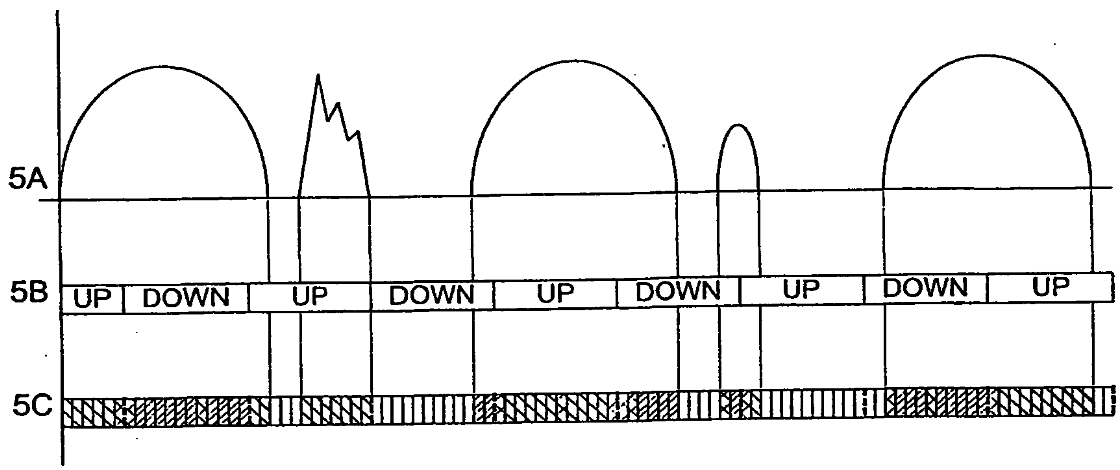

5A
5B
UP
DOWN
UP
DOWN
UP
DOWN
UP
DOWN
UP
5C

FIG. 5

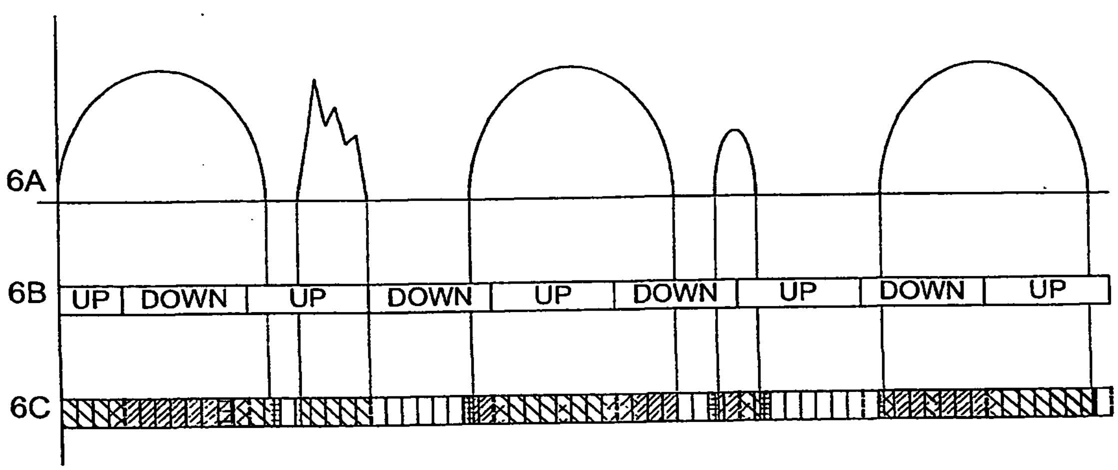

6A
6B
UP
DOWN
UP
DOWN
UP
DOWN
UP
DOWN
UP
6C

FIG. 6

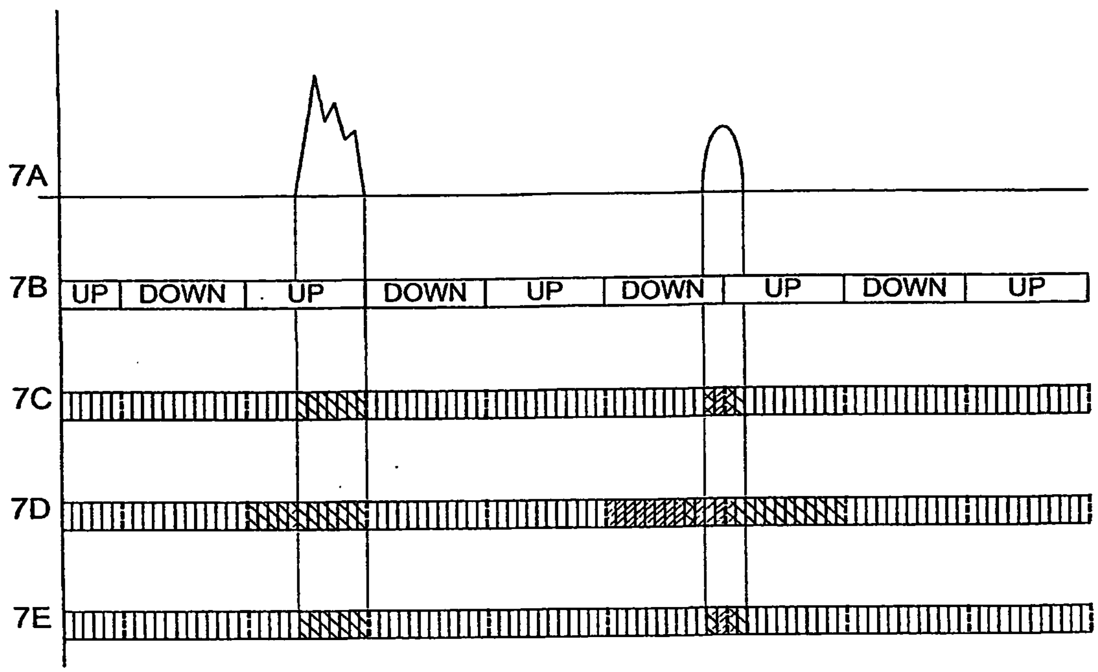


FIG. 7

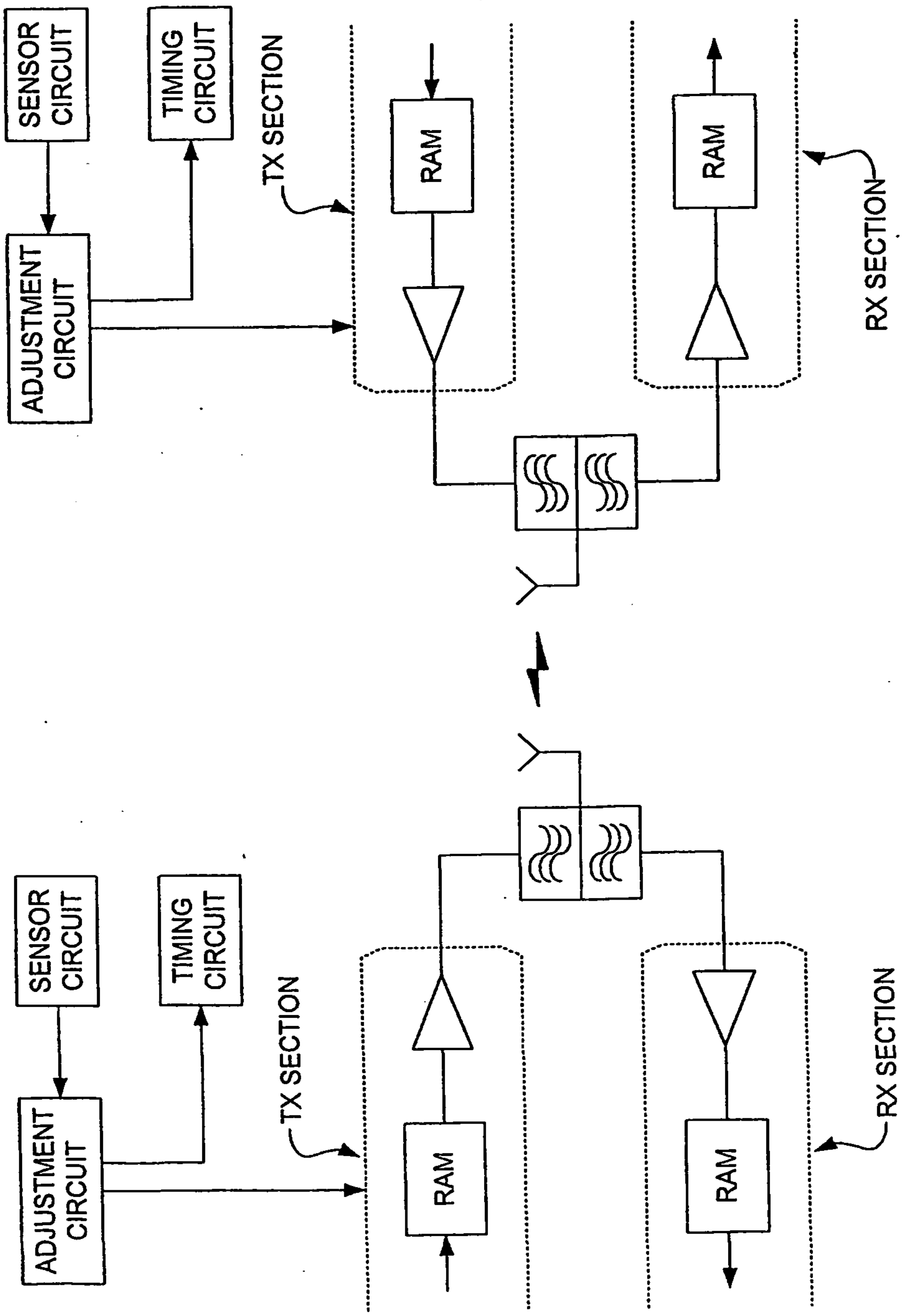

SENSOR CIRCUIT
TIMING CIRCUIT
ADJUSTMENT CIRCUIT
TX SECTION
RAM
RAM
RX SECTION
SENSOR CIRCUIT
TIMING CIRCUIT
ADJUSTMENT CIRCUIT
TX SECTION
RAM
RAM
RX SECTION

FIG. 8

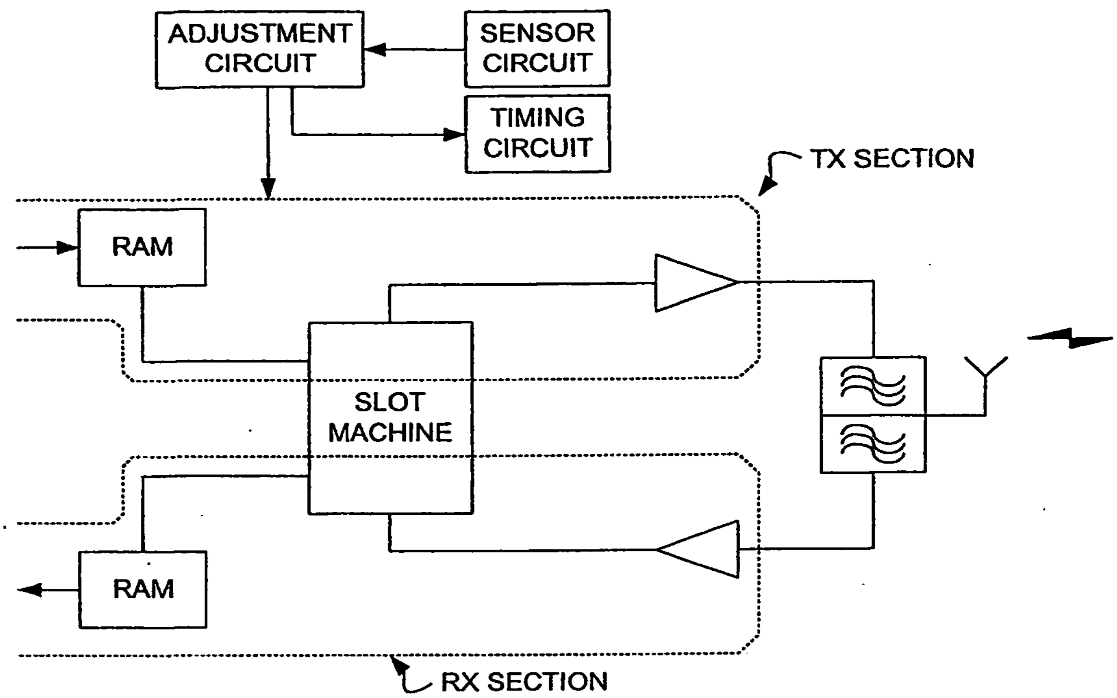
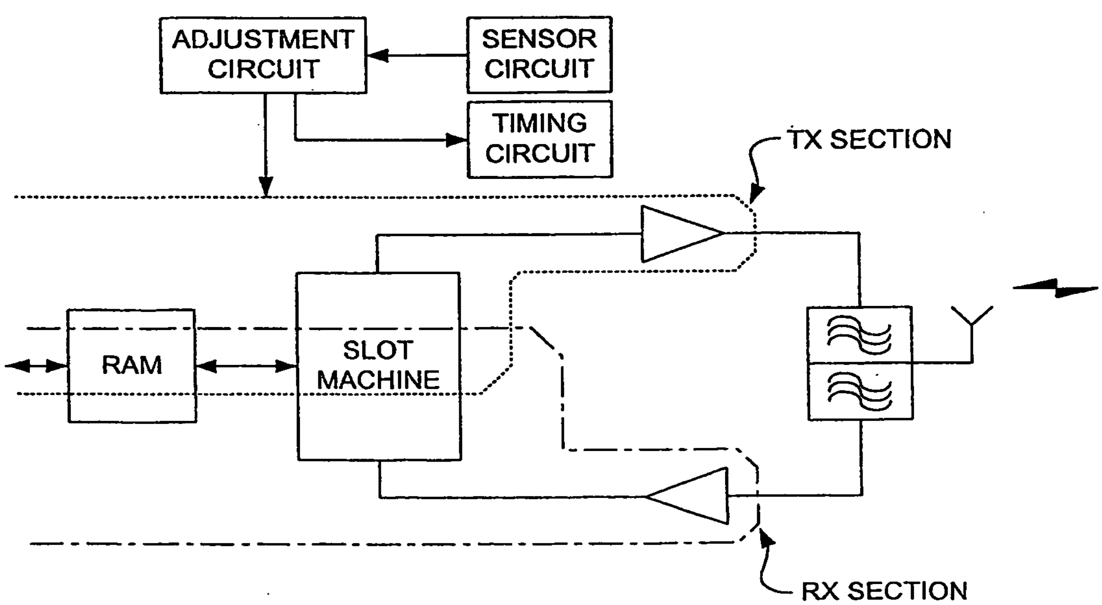

ADJUSTMENT CIRCUIT
SENSOR CIRCUIT
TIMING CIRCUIT
TX SECTION
RAM
SLOT MACHINE
RAM
RX SECTION

FIG. 9


ADJUSTMENT CIRCUIT
SENSOR CIRCUIT
TIMING CIRCUIT
TX SECTION
RAM
SLOT MACHINE
RX SECTION

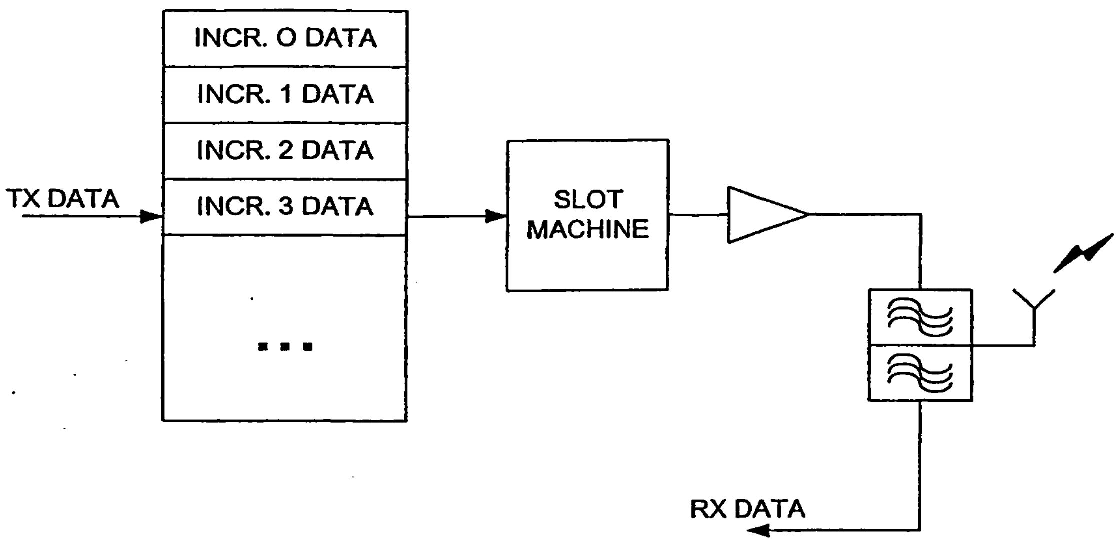


FIG 10A

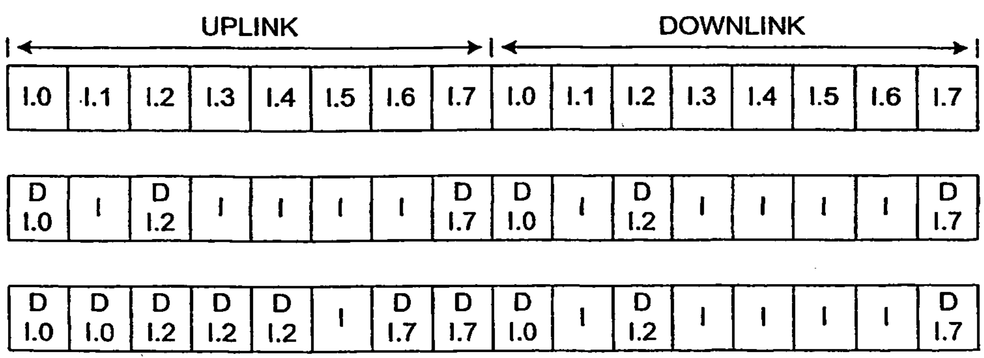


FIG. 10B

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/40089

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B1/10 H04B1/707 H04L12/28 H04L1/00 H04Q7/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 935 347 A (HARRIS CORP) 11 August 1999 (1999-08-11) column 5, line 22 -column 6, line 37 column 7, line 10 -column 8, line 6	1-7, 17-21, 30-38
A		8
X	US 5 459 727 A (VANNUCCI GIOVANNI) 17 October 1995 (1995-10-17) column 10, line 21 -column 11, line 20	22-29
Y		11-13, 15,16
Y	US 5 574 979 A (WEST GUY J) 12 November 1996 (1996-11-12) abstract	11-13, 15,16

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 August 2001	21/08/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Martinez Martinez, V

International Application No
PCT/US 01/40089

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 818 831 A (OTONARI MIKI) 6 October 1998 (1998-10-06) column 6, line 41 -column 7, line 51; figure 3 ---	11-16, 22-29
A	EP 0 963 051 A (EASTMAN KODAK CO) 8 December 1999 (1999-12-08) column 3, line 3 -column 4, line 31 ---	5,6,20, 21,27,28
A	MIYAMOTO S ET AL: "EFFECT OF MICROWAVE OVEN INTERFERENCE ON THE PERFORMANCE OF DIGITALRADIO COMMUNICATIONS SYSTEMS" 1997 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS. MONTREAL, JUNE 8 - 12, 1997, IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS (ICC), NEW YORK, NY: IEEE, US, vol. 1, 8 June 1997 (1997-06-08), pages 51-55, XP000740202 ISBN: 0-7803-3926-6 the whole document -----	11-16

INTERNATIONAL SEARCH REPORT

Information on patent family members

ational Application No
PCT/US 01/40089

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0935347 A	11-08-1999	US 6006071 A	21-12-1999
		AU 9826198 A	29-07-1999
		CN 1239849 A	29-12-1999
		SG 72915 A	23-05-2000
US 5459727 A	17-10-1995	CA 2054591 A,C	29-08-1992
		JP 2828826 B	25-11-1998
		JP 4337997 A	25-11-1992
		US 5513184 A	30-04-1996
US 5574979 A	12-11-1996	NONE	
US 5818831 A	06-10-1998	JP 9023205 A	21-01-1997
		CN 1141545 A	29-01-1997
EP 0963051 A	08-12-1999	JP 2000013334 A	14-01-2000